

Cooperative Learning: Developing an Observation Instrument for Student Interactions

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Abstract - ABET states in Criterion 3(d) that engineering students should demonstrate “an ability to function on multi-disciplinary teams.” As we enter an era of globalization, industry is placing a greater emphasis on engineers who can engage in collaborative working environments, i.e. teams. Engineering educators must teach engineers the relevant content but also train them to interact and work productively in collaborative teams. The model of cooperative learning, developed by Johnson and Johnson, and applied to engineering by Smith, specifies instructional use of small groups (or teams) where students work together in an effort to maximize their own and others learning. The researchers state that carefully structured cooperative learning strategies involve the elements of *positive interdependence, individual and group accountability, opportunities for group processing, a focus on developing social skills, and promotive face-to-face interaction*. The authors of this paper have developed a classroom observation instrument for evaluating the elements of cooperative learning and teaming in an engineering setting. This paper presents and discusses the development of this mixed methods observation tool, that captures observed instances of cooperative learning and teaming among engineering students engaged in content and course assignments as well as evaluates the effectiveness of the observed instance for each element.

Index Terms – Cooperative learning, Cooperative learning elements, Observation protocol, Teaming.

INTRODUCTION

The accelerating rate of technology introduction and adoption in our society will require individuals who can successfully apply and expand upon their fundamental knowledge of science, technology, engineering, and mathematics (STEM) to create effective solutions to the world’s emerging problems. In other words, the fast-moving, global, multidisciplinary industrial environments will require engineering graduates to not only have the traditional technical knowledge of their predecessors, but also a new and broader skill set. They will also need to understand and apply several disciplines to solve complex problems, adapt to new technology and changing situations, combine ideas to synthesize creative solutions, and work effectively in cooperative groups or teams while having excellent communication skills [1]. Unfortunately, adequately preparing future engineers, scientists, and technicians for

“tomorrow’s world” is only part of the problem. Recent data suggest that the United States will be unable to meet its technological demand with the current/future workforce [2].

A classroom observation instrument for evaluating the elements of cooperative learning and teaming in an engineering setting was developed. This paper discusses the development of this mixed methods observation tool. It is a mixed methods instrument in that frequency and evaluation of observed instances, through detailed field notes, of cooperative learning and teaming among engineering students are recorded while students engage in content and cooperative course assignments. It is believed that this tool will assist engineering instructors in evaluating the effectiveness of the students’ interactions and learning in cooperative classroom task, but also inform them about directions for instruction.

COOPERATIVE LEARNING

Johnson, Johnson, and Holubec [3], define *Cooperative Learning* as an instructional strategy that draws benefit from the interaction of students working in small teams to maximize their own as well as the learning of the other students in the team. Cooperative learning has been implemented in numerous educational settings, including a variety of content areas, grade levels, and instructional institutions. Overall, the effect of cooperative learning has been demonstrated to show positive effects on academic achievement, student attitudes, social ability, retention, and self-esteem.

Cooperative learning is derived from Deustch’s [4-5] social interdependence theory. Cooperative learning strategies are derived from three theoretical perspectives; cognitive development, behavioral and social interdependence theories. Based on theories of Piaget and Vygotsky, cognitive development theory suggests that cooperative efforts effect cognitive development. According to Piaget [6] when individuals cooperate their interaction creates opportunities for social cognitive conflicts, which cause cognitive disequilibrium. Thus, this cognitive disequilibrium improves one’s ability to consider other perspectives or ideas effecting the cognitive development of individuals who engage in cooperative interactions. Partially connected to this perspective, Vygotsky [7] proposed that knowledge is the result of a person’s cooperative effort to learn; therefore, it is social, and for cognitive development to occur cooperative efforts are necessary.

The theory, research, and practice of cooperative

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learning have had a strong and quantifiable history in education. According to Johnson & Johnson [8], “Since 1898 over 550 experimental and 100 correlational research studies have been conducted on cooperative, competitive, and individualistic efforts.” However, this idea of strength in numbers extends to the theories of how people should work together—learning together is more rewarding, and perhaps more effective than learning alone or even more rewarding than learning competitively.

The five essential elements of cooperative learning are positive interdependence, individual accountability, group processing, social skills, and face-to-face interaction [8-9]. Without these elements established in the learning process, cooperative learning is not the same as group work. The teacher’s role in cooperative learning is to guide and support student interactions using base groups, formal, or informal learning groups. This is a deeply relationship-based instructional strategy, as well as learning strategy that encourages all students to feel a part of the classroom community and promote learning success for all students.

OBSERVING THE ELEMENTS OF COOPERATIVE LEARNING

There is overlap in the type of skills that one observes among the individual elements of cooperative learning. As an instructional strategy Johnson, Johnson, and Holubec [3] suggest that all elements (eg. PIGS—Face) should be included or present in cooperative learning situations. However, the focus of the observation instrument is to delineate the specific skills or characteristics for each element in an effort to evaluate team/group functioning and to inform instructors in which elements they should attend to during cooperative activities and skill building. In an effort to tease out the characteristics necessary for each element, this paper attempts to articulate the skills and objectives needed for each element (Table 1).

TABLE 1
PIGS-FACE—ELEMENTS OF COOPERATIVE LEARNING

	Element	Characteristic
P	Positive Interdependence	<ul style="list-style-type: none"> Relationships Contribution of group members
I	Individual Accountability	<ul style="list-style-type: none"> Individual participation Performance dependent on all group members
G	Group Processing	<ul style="list-style-type: none"> Functioning Clear goals, processing events
S	Social Skills	<ul style="list-style-type: none"> Communication Clarification, paraphrasing, praising
F	Promotive Interaction	<ul style="list-style-type: none"> Encouragement Facilitated communication

Positive interdependence

Interdependence is the perception that team members are linked with each other in a way so that individual members cannot succeed unless they do their work [8]. As such the, individual work benefits the team and the teamwork benefits

the individual. Research on promoting positive interdependence shows giving individuals specific role assignments within the group is considered a promotive activity [10]. Positive interdependence is enhanced by having a group goal in which each person must contribute [3] and in having structured activities that promote student learning as a group [11]. However, while cooperative learning theory suggests that positive interdependence is a necessary condition for a cooperative effort, little to no research exists about the students’ perceptions of instruction that is specifically aimed at creating a sense of *positive interdependence* within the team/group.

The researchers used the above definition to guide their identification of *positive interdependence* in the team observations. In order to identify *positive interdependence*, the researchers looked for examples of the following characteristics: dynamics of the relationships between group/team members, group acknowledgment and engagement with task goals, objective, and process, and cohesiveness among member in accomplishing the task. Team’s scored well on *positive interdependence* when the members showed evidence of progressing toward the goals of the task with understanding and thoughtfulness. Examples of this might be that the team chose directions to work that progressed them toward the outcome required by the task, and everyone on the team made strides toward this accomplishing the task at hand.

Individual accountability

Accountability exists when the performance of each student is assessed and the results are given to the team and the individual. Students learn together so they can subsequently perform higher than as individuals [8]. Simply having clearly defined rules and criteria for grading without making each person accountable does not consistently produce greater achievement [11]. Research has shown that providing “improvement scores” for individuals and for the group provides a sense of accountability [12]. Unfortunately, research also shows that use of such a scoring method can be initially perceived negatively by high achievers who have less room to improve their grade—these students tend to prefer working alone, as they feel that they can only depend on themselves [13]. Other than a few studies, again little to no other research exists about the students’ perceptions of instruction that is specifically aimed at creating a sense of *Individual Accountability* within the team/group.

Again, the researchers used the given definition of *individual accountability* to identify teams’ use of this element of cooperative learning. The following characteristics of team interaction aided in the researchers ability to identify the use of this element: individual participation by each member of the team and team members’ expectations for individual participation. When all team members were actively participating and expecting each other to participate, teams were observed as having high *individual accountability*. There is also an instructor piece to individual accountability which is not taken into account in the observations of each team’s interactions.

Group processing

Group processing is used to clarify and improve the effectiveness of the members in contributing to the collaborative efforts of the group. Johnson and Johnson [14] state that an effective work group is influenced by whether or not the groups reflect on how well they are functioning. As such, the cooperative process must be an identifiable sequence of events taking place over time. Including process goals in the sequence of events are instrumental in the effort for achieving task goals. Groups must be given opportunities to reflect on the goals of a task as well as provide rationales and make decisions about how the actions taken support achievement of the goals. Again, while the theory suggests that group processing is a necessary condition for a cooperative effort, little to no research exists about students' perceptions of instruction that is specifically aimed at having students incorporate *group processing* into their team/group processes.

The following characteristics of the group activity or task were observed for the cooperative learning element *group processing*: individuals function as a cohesive team, the team set and reflected about the goals of the task, and the team reflected about the process toward completing the task. For example, a team that paused every once in a while to assess what the team had done up to that point and reevaluated their plan for continuing scored high on the *group processing* element of cooperative learning.

Social skills

Social skills are known to contribute to the success of a cooperative effort through the engagement of appropriate interpersonal skills. Research indicates that development of such skills is possible in the cooperative learning environment [11]. Such skills include group members asking for clarification, paraphrasing, acknowledging contributions, asking others to contribute, praising others, and mediating conflicts [15]. However, while the theory suggests that having appropriate *social skills* is a necessary condition for a cooperative effort, again little to no research exists about students' perceptions of instruction specifically aimed at having students incorporate *social skill* development into their team/group processes.

The following characteristics of the group activity or task were observed for the cooperative learning element *social skills*:

- Use of proactive communication and social skills, i.e. eye contact while talking to other group members, respecting ideas of all group members.
- The group engagement in forming, functioning, and fermenting about the task.

Face-to-face promotive interaction

Promotive interaction occurs when “individuals encourage and facilitate the efforts of other’s to achieve and complete task in order to reach the group’s goals” [3]. Johnson and Johnson have retreated from the notion that promotive interactions

must be face-to-face. In this climate of technological advances such as video conferencing, teleconferencing, and other ways to communicate, has changed the way in which people communicate. The essential element for interaction is they must be facilitated in such a way that they are promotive. That is, group members are able to provide each other with efficient and effective help or assistance toward accomplishing the goal. Once again, while the theory suggests that face-to-face promotive interaction is a necessary condition for a cooperative effort (even in the recently modified definition of what “face-to-face” means), there is little to no research to describe students' perceptions of instruction specifically aimed at creating a *Face-to-face promotive interaction* environment for the team/group.

The following characteristics of the group activity or task were observed for the cooperative learning element *promotive interaction*: all members' ideas are heard and valued, and all members actively contribute to design and processing of task. This is an overall attitude of the team members toward one another. Here the researchers looked for signs that the team members were helping one another succeed, being mindful of everyone's ideas, being inclusive of all members of the team, and using constructive critique rather than hurtful criticism.

COOPERATIVE LEARNING OBSERVATION PROTOCOL

The Cooperative Learning Observation Protocol (CLOP) is an observation instrument that was developed and piloted at the University of Minnesota. This observation instrument is based on the CEPT-Core Evaluation Classroom Observation Protocol, a widely used instrument to record and evaluate teacher's instructional activity [16] and the elements of cooperative learning. The CLOP is a criterion-referenced instrument used to describe and evaluate student interactions during group activities in the classroom. The research team was specifically interested in recording and measuring the occurrences of the elements of cooperative learning as articulated by Johnson and Johnson (ie. PIGS-Face—positive interdependence, individual accountability, group processing, social skills, and promotive interaction) [3]. In order to effectively assess the overall effectiveness of a cooperative learning activity, a comprehensive view of students' active interaction and how students engage in the task is needed. Thus, the CLOP is designed to delineate cooperative learning skills and objectives over time, while students engage in classroom directed cooperative learning tasks.

The protocol has several parts. In the first part prompts and space are provided to capture a description of the general demographics of the classroom and class including items such as type of course, number of students, and description of the physical environment of the classroom. The second part prompts and space are provided to include details of the context of instruction leading up to the task. The third part, the evaluative section, provides space and prompts to record the activity of the group, the major interactions, and rate the interactions occurring in each five-minute interval of the observed cooperative learning activity. The observed

interactions are coded according to level of group involvement in the five elements of cooperative learning (interdependence, individual accountability, group processing, social skills, and promotive interaction). For the purposes of this study, the cooperative learning elements—PIGS—Face—will be referred to as “elements”. Coding the elements of cooperative learning provides an evaluative rating (high, medium, low) of the student’s achievement and attention to the skills of cooperative learning in the cooperative learning activity. It is important that all sections are completed to provide an accurate “snapshot” of the cooperative learning skills being used and attended to during cooperative learning activities.

CLOP DEVELOPMENT

The CLOP was developed to evaluate the overall effectiveness of cooperative learning skills used by students as they engage in cooperative tasks in the classroom. In evaluating students’ engagement in the skills necessary for effective group and individual student learning, it was hypothesized that the five elements for cooperative learning would be necessary. The researchers were interested in measuring the frequency and quality of occurrence of the elements. By drawing on the characteristics of CEPT-Core Evaluation Classroom Observation Protocol [16], the CLOP was created to record activity in five-minute intervals.

Setting

The protocol was piloted in a graduate level software design and management course. Students engaged and were evaluated on a long-term project cooperative project and participate in several classroom collaborative activities, that are generally used to practice and model the design concepts addressed in class lecture. The course met once a week for 18-weeks, the duration of each class was 4-hours, where approximately 20 minutes was dedicated to group activity. Most classroom time was spent listening to lectures of design concepts and skills, while time to work on the project occurred outside of the regular class period. Only the student interaction in classroom team activities was evaluated using the CLOP.

CLOP, Task, Course, and Student Information

The CEPT-Core Evaluation Classroom Observation Protocol [16] was a model for developing the CLOP. This provided a template to record and rate occurrence of activities that were appropriate for effective cooperative learning. Before observations of student-group activity, the researchers collaborated to create a list of items and characteristics to be observed and recorded. Contextual characteristics such as course, instructor, and time of day, room arrangement, and overall student demographics in the classes were deemed important. Additionally, group characteristics, such as team composition, cooperative task, were included in the initial version of the CLOP. Figure 1 shows a condensed version of the data collection instrument used to collect these data. This table is at the top of each of the versions of CLOP discussed in this paper.

The top section allowed the researcher to give details about the course and instructor, plus the make-up of the student population and the instructional context in which the teams would be participating in the cooperative learning task or activity. The “group specifics” section provides space for the researcher to detail information about the specific group being observed, such as the group name, the type of seating arrangement the group was in, and the number of students in the group. The final section, “Cooperative Task(s),” allowed the researcher to capture the task in which the teams were engaged.

Cooperative Learning Observation Protocol				
Course/Level		Date		
Observer		Instructor		
Number of Students in Class		Whole Class Demographic Information:		
Instructional Context:				
Group Specifics				
GROUP #/Name		Seating Arrangement		
Group Composition (heterogeneous/homogeneous)		Length of class		
Number of Students in Group		Female	Male	
Other:				
Cooperative Task(s)				

FIGURE 1
CLOP, TOP SECTION- PROVIDES SPACE FOR THE DETAIL OF THE COURSE, STUDENTS, AND TASK.

CLOP, version-1

The first version included space to record field notes while rating and recording the elements (Figure 2). In the column next to the cooperative learning element (PIGS—Face) an observer would record an evaluative score for the observed characteristics of the element in the given time interval, 3-high, 2-medium, or 1-low. In the notes column, observational records such as transcripts of group discourse, task activity and/or goals would be recorded.

Interval	Element	Notes
0-5	P	
	I	
	G	
	S	
	F	
5-10	P	...Repeat spacing for length of cooperative activity

FIGURE 2
CLOP, VERSION-1, FIELD NOTES SECTION- FIVE MINUTE INTERVAL.

CLOP, version-2

After observations of the first classroom cooperative group activity, the researchers noted that key lesson context characteristics were needed. In order to make sense of the group activity, lesson characteristics, and task relevance were recorded. For example, a classroom task such as brainstorming about designing and writing computer code for an interactive computer game is a very different task from developing a work plan to design, promote, and develop a comprehensive “open-source” computer project. The researchers found that additional information such as lesson objectives, task objectives, and instructional relevance were necessary to understand the significance of the elements in relation to the given task.

To aid in the organization of the instrument, columns for indicating the engagement of each element were added, so that the observer could quickly indicate the engagement level as low, medium, high, or not observed. This provided the observer a simple check off place, so they could spend more time recording field notes and impressions of activity (Figure 3).

Interval	Element					Notes
	L	M	H	N		
0-5	P					
	I					
	G					
	S					
	F					
5-10	P					...Repeat spacing for length of cooperative activity

FIGURE 3

CLOP, VERSION-2, FIELD NOTES SECTION-FIVE MINUTE INTERVAL.

CLOP, version-3

After observing several cooperative group tasks and activity using the CLOP, version-2 the researchers determined the structure of cooperative learning activities was particularly important. It was apparent that the students’ involvement in a single element was determined by the task as well as the particular component of a task. For example, at the beginning of a task, the students would tend to engage in group processing to identify the objectives and purpose of the task, as opposed to a stronger focus on promotive interaction that was observed at the end of a task when students were more aware of the participation of all member of the group. This being the case, a column was added to the field notes section to allow for recording the pertinent task or activity (Figure 4).

Interval	Task/Activity	Element					Notes
		L	M	H	N		
0-5		P					...Repeat spacing for length of cooperative activity
		I					
		G					
		S					
		F					
5-10		P					

FIGURE 4

CLOP, VERSION-3, FIELD NOTES SECTION-FIVE MINUTE INTERVAL.

CLOP, version-4

Another revision of the CLOP (CLOP, version-4) was deemed necessary during the validation and training of other researchers in using the tool. Two major changes were made, elimination of the task/activities column in the field notes section and removal of the social skills element from the observation sections. These changes were justified as the research team attempted to eliminate all overlapping and non-teaming functioning behaviors from the instrument (Figure 5).

Interval	Element					Notes
	L	M	H	N		
0-5	P					
	I					
	G					
	F					
5-10	P					...Repeat spacing for length of cooperative activity

FIGURE 5

CLOP, VERSION-4, FIELD NOTES SECTION-FIVE MINUTE INTERVAL.

Justification for eliminating the task/activity column from the field notes section was due to the fact that a detailed description of the cooperative task/activity is asked for in the contextual and demographics section in the beginning of the CLOP instrument. Justification for eliminating social skills from the incremental observations was considered necessary to avoid overlap of similar or equivalent constructs. The research team determined it was impossible to separate this element from the other four elements (PIG-Face) of cooperative learning. The Social Skills element encompasses the other four cooperative learning elements, as this element focuses on the behavioral aspects of all four of the other elements. Social Skills, as articulated by Johnson, Johnson, and Holubec [3], is divided into four sub-elements that map to the other four elements: Forming, Functioning, Formulating, and Fermenting. Because social skills was designed more as an implementation element rather than a single concrete, observable element in teamwork, the researchers incorporated all of the behavioral pieces of the social skills element into the other four elements of PIGS-Face (positive interdependence, individual accountability, group processing, and promotive interaction).

Furthermore, the research team decided that for consistency of observations, descriptions and examples of distinguishing characteristics for each element would be appropriate to include in the beginning of the observation/field notes section of the instrument. A shortened summary detailing observational characteristics (Figure 6) acts as a quick reference guide to facilitate the researcher as to what characteristic aligns with which element. In addition, the researchers have generated a rubric, describing low, medium, and high characteristics of each element. This rubric will be made available in future publications.

REFERENCES

(P): There is evidence of group cohesiveness for accomplishing the task.	(I): Individual group members take responsibility for individual efforts and contributions towards the team.	(G): Use ways to improve the processes team members use to maximize their learning.	(F): Promote one another's success, through a supportive, encouraging, and praising environment.
Examples: <ul style="list-style-type: none"> ▪ Roles as needed <ul style="list-style-type: none"> ○ Facilitator, encourager, timekeeper, etc. ▪ Contributing unique background & skill 	Examples: Individual: <ul style="list-style-type: none"> ▪ Participation ▪ Contribution ▪ Engagement ▪ Ability to articulate & justify group procedures & results ▪ Group makes sure all understand task & procedures 	Examples: <ul style="list-style-type: none"> ▪ Feedback to one another about team effectiveness ▪ Setting goals or sub-goals ▪ Reflection on success ▪ Key sayings "What we have so far" "Does everyone understand where we are?" 	Examples: <ul style="list-style-type: none"> ▪ Eye contact ▪ Name use ▪ Appropriate interruptions ▪ Student suggestions respected ▪ Conflict is managed ▪ Stimulate each other to draw out new ideas ▪ Celebrate success

FIGURE 6
CLOP, VERSION-4, EXAMPLES OF ELEMENTS

INTER-RATER RELIABILITY

In order to test the instrument for reliability and validity, two researchers simultaneously observed four separate cooperative learning groups and used CLOP to rate the cooperative teams. The absolute percent agreement for the four ratings was 75% and 95% of ratings fell within one point difference. The calculated Cohen's Kappa [17-18] for the inter-rater reliability agreement was $\kappa = 0.67$. According to Landis and Koch [19], this is "substantial agreement," which is only second to "almost perfect agreement."

CONCLUSION

The *Cooperative Learning Observation Protocol, CLOP*, has demonstrated to be a useful instrument to rate student collaboration and effectiveness in the elements of cooperative learning as specified by Johnson, Johnson, and Smith [20]. The researchers used this tool to evaluate cooperative interactions among students working in teams/cooperative groups while observing the team working on specific cooperative tasks and activities. This tool allows observers to report on the team attributes of the five elements of formal cooperative teams. The researchers will use this tool to rate students' effectiveness (high, medium, low, or not observed) of the elements of cooperative learning [20], as well as take field notes.

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